i) The sewer dimensions where drilling was completed were on the order of 54 inches - MH'A' (BH11-92); enlarging to 60 inches at MH'B' (BH12-92); sewer construction was completed in 1917.

ii) The sewer pipe was vitrified clay segment blocks (i.e. clay blocks with a 54- or 60-inch diameter hole) placed into the rock cut and likely backfilled with concrete. Backfill details were not available. The sewer contract documents were missing from City records for this section of sewer. Common practice for this type of sewer was to use concrete as a backfill material.

iii) Plan #309 indicated that an open cut extended southward from the area of MH'A'. It did not describe the installation method north of this point. Tunneling may have been performed from MH'A' north to Royal Avenue, but the City Engineering Department did not think it was likely.

iv) During the visit to the City Engineering Department, a markup of Plan #309 was observed which described an internal inspection of the 54 and 60-inch sewer. The date, time and who conducted this inspection were not referenced on the markup. Written comments observed on the markup stated that numerous points of groundwater leakage into the sewer were observed along the top, the bottom and sides of the sewer, and that the volume of infiltration observed range from minor quantities to large quantities. No estimate of the volumes were indicated on the markup. The comments observed on the markup show groundwater infiltration to the ISSS was occurring during the time period of the inspection.

2.2.2 Sewer Bedding Borehole Locations

Figure 2.4 shows the sewer bedding borehole locations adjacent to the sanitary sewer. In total 11 boreholes were drilled in two separate areas along the sanitary sewer length (MH'A'/MH'B'). All borings were completed adjacent to existing sanitary manholes to insure that the location of the sewer was defined and to prevent any possibility of drilling into the sewer. Four borings (BH11-92, BH11A-92, BH11B-92 and BH11C-92) were completed in the vicinity of MH'A' with the initial borehole converted to a shallow bedrock monitoring well (BH11D-92). Seven boreholes (BH12-92 and BH12A-92 through BH12F-92) were completed in the vicinity of MH'B'.

2.2.3 Borehole Procedures

The borings were installed using 8-inch outside diameter hollow stem augers. Samples were collected in advance of the augers using 2-inch diameter split spoon samplers. Visual examination of the soil materials was noted and samples for a geologic record were collected and stored for future reference at the Plant.

Each boring was installed adjacent to an existing manhole to permit a visual reference with the sewer pipe and allow an exact measurement to the invert of the sewer. An attempt was made to sample continuously until the base of the sewer bedding was encountered or until the maximum depth of the sewer was passed, whichever was deeper.

Once the boreholes were completed, they were backfilled with cement/bentonite grout using positive placement techniques. The top six inches of each borehole was backfilled with material which matched existing surface materials.

BH11-92

BH11-92 was located west of Union Carbide, south of Royal Avenue and north of OSI well OW652. The boring was completed near the third manhole south of Royal Avenue (designated MH'A') along the 54-inch ISSS. The expected depths to the top of the sewer pipe, to the invert of the sewer pipe, and to the top of the bedrock near the third manhole were obtained from Plan #309 and are as follows:

	Elevation (ft. AMSL)	*Depth (ft. BGS)*
Ground Surface	570.3	0
Bedrock Surface	554.4	15.9
Top of Pipe	551.8	18.5
Invert of Pipe	547.4	22.9

Four attempts were made to advance the borehole beyond the top of pipe elevation with no success. Bedrock was encountered between 16.7 and 16.8 feet BGS. This demonstrated that the bedrock in the immediately adjacent areas was not disturbed during construction of the sewer.

In order to obtain additional information, an exploratory bedrock corehole (BH11D-92) was drilled in the area adjacent to MH'A'.

A 4-inch inside diameter black steel casing was installed to the top of bedrock (auger refusal) and grouted in place. A hydrostatic test was conducted to check the overburden seal. The overburden seal passed the hydrostatic test and coring proceeded from 17.8 feet BGS to a depth of 26.9 feet BGS. The bedrock log for BH11D-92 is presented in Appendix A. At completion, the bedrock exploratory boring was secured with a flush mount protective cover.

A highly fractured dolostone in a gray and pink gray cement matrix was found in the interval 17.8 to 19.7 feet BGS. Bedrock from 19.7 to 26.9 feet BGS consisted of a weathered to slightly weathered dolostone (Oak Orchard Formation). No visual or olfactory evidence of NAPL or chemical presence was noted from the core or in the water circulated during the bedrock drilling.

<u>BH12-92</u>

BH12-92 was located west of Union Carbide and south of Royal Avenue and OSI well OW654. The boring was completed near the second manhole south of Royal Avenue (designated MH'B') along the

54-inch diameter ISSS. The expected depths to the top of the sewer pipe, to the invert of the sewer pipe, and to the bedrock near the second manhole south of Royal Avenue were obtained from Plan #309 and are as follows:

	Elevation (ft. AMSL)	*Depth (ft. BGS)*
Ground Surface	569.95	0
Bedrock Surface	555.4	14.6 feet
Top of Pipe	551.1	18.9 feet
Invert of Pipe	546.76	23.2 feet

A visual check inside this sewer manhole revealed a ledge or benching at approximately 12 feet BGS. As a result, an accurate field measurement of the invert of the 54-inch pipe could not be obtained. Groundwater infiltration along the sidewall approximately 11 feet BGS was observed.

Six attempts were made to advance the borehole beyond 14.7 feet BGS with no success. This elevation matched the expected elevation of the top of bedrock demonstrating that the bedrock immediately adjacent to the sewer was not disturbed during the construction of the sewer.

2.2.4 Chemical and Hydraulic Monitoring • BH11D-92

Two rounds (Rounds 1 and 2) of groundwater hydraulic and chemical monitoring were performed during Phase 2 of the OSI. In conjunction with the Phase 2 Round 1 bedrock groundwater hydraulic and chemical monitoring activities, BH11D-92 was sampled once and analyzed for the SSI parameters. The results of this analysis are presented and discussed in Section 4.0.

Prior to this sampling event, a groundwater level was recorded from BH11D-92.

2.3 BEDROCK WELLS - CHEMICAL AND HYDRAULIC MONITORING

The following subsections describe the procedures and protocols to complete the bedrock hydraulic and chemical monitoring tasks during Phase 2 of the OSI.

Two rounds (Rounds 1 and 2) of SSI sampling and analysis were completed at each Phase 2 bedrock well and selected existing wells. Figures 2.5 and 2.6 show the bedrock well locations selected for hydraulic and chemical monitoring, respectively. A summary of the bedrock wells sampled and monitored is shown on Table 2.1.

2.3.1 Hydraulic Monitoring/Well Depth Soundings • Bedrock

Water level elevations were measured for all SDCP wells (except A-Wells), all OSI wells and selected existing wells on adjacent properties prior to each sampling round. The bottom of each OSI well was sounded to determine whether silting of these wells had occurred. The results of the depth sounding program are recorded in Table 2.2. Groundwater contours prepared from the water level data (May 1993 and July 1993) are shown on Figures 2.7 through 2.12 for the D, C and B bedrock zones.

2.3.2 Bedrock Groundwater Sampling Locations

Bedrock groundwater samples for the OSI Phase 2 SSI Rounds 1 and 2 were collected during May and July 1993 respectively. The bedrock wells sampled for each round are shown on Table 2.1.

A few wells were sampled only during Round 1. These included three existing OSI bedrock wells (OW650D, OW652D and OW653D), one ISSS well (BH11D-92) and a NYPA well (PASNY 139) located north of Royal Avenue and east of the NYPA Power Conduits.

2.3.3 Sampling Procedures

The sampling protocols used during the OSI - Phase 2 program were those described in the following SDCP documents:

i) Appendix A - Site Operations Plan - April 1988

Section 8	-	well development, well preparation and well sampling
Section 10	-	waste handling
Section 11	-	equipment cleaning

ii) Appendix C - Chemical Sampling and Quality Assurance Plan - April 1988.

Sections 3.6, 6	-	general description of program
	-	sampling requirements
	-	all QA/QC requirements

After development and prior to purging for Round 1, each well was allowed to stabilize over a period of at least 30 days. The sampling process included the measurement of static water levels at each well (Section 2.3.1) followed by well purging. Each bedrock well was purged a minimum of five well volumes. Following purging, pH and specific conductance were measured.

2.3.3.1 Field QA/QC

Field QA/QC requirements with respect to field blanks and sample duplicates were met. One blind sample duplicate and one field blank were submitted for analysis during each Round. The field blank was collected using a bottom loading bailer to check decontamination procedures. Distilled deionized water was used for the field blank.

2.3.3.2 State Split Samples

The State elected not to receive split samples during the OSI - Phase 2 activities (Round 1 and Round 2 - SSI Survey).

2.3.4 Analytical Parameters

The Phase 2, Round 1 and Round 2 groundwater samples were analyzed for the parameters listed on Table 2.3.

2.4 OVERBURDEN WELLS - CHEMICAL AND HYDRAULIC MONITORING

For OSI Phase 2, two rounds (Rounds 1 and 2) of hydraulic monitoring were completed at selected OxyChem overburden wells located in the northeast sector of the Plant and UDG wells MW-1, MW-2 and MW-3 (see Table 2.1). Two UDG wells (MW-2 and MW-3) were sampled for chemical analysis during Round 1 and one UDG well (MW-1) was sampled during Round 2. Figure 2.13 shows the overburden well locations selected for chemical and hydraulic monitoring.

2.4.1 Hydraulic Monitoring • Overburden

Water level measurements were measured prior to the Round 1 and Round 2 sample events (May and July 1993). The overburden groundwater levels for May and July 1993 are shown on Figures 2.14 and 2.15, respectively.

2.4.2 Sampling Locations • Overburden

UDG overburden wells MW-2 and MW-3, located on the UDG property adjacent to the northeast boundary of the Plant, were sampled once (Round 1) and UDG overburden well MW-1 was sampled once (Round 2) during the OSI - Phase 2 activities.

2.4.3 Sampling Procedures

The sampling protocols used during the OSI - Phase 2 program were described in Section 2.3.3.

The sampling process included the measurement of static water levels at each well followed by well purging. Each overburden well was purged a minimum of five well volumes. Prior to completion of purging, temperature, pH and specific conductance were measured.

2.5 GENERAL PROGRAM PROTOCOLS

The following subsections describe the protocols which were used for Waste Material Handling, Health & Safety and Equipment Cleaning. Section 2.5.4 describes the program modifications which were necessary due to conditions encountered during the course of the OSI - Phase 2.

2.5.1 Waste Material Handling

All wastes generated as a result of OSI Phase 2 activities including aqueous phase liquids, soils, rock cuttings, and safety equipment (e.g. Tyveks, gloves) and used sampling equipment (e.g. tubing) were collected and handled in accordance with Section 10 of Appendix A of the SDCP.

2.5.2 Health and Safety

Health and safety protocols implemented during the installation of the overburden and bedrock wells were as described in Appendix B of the SDCP.

2.5.3 Equipment Cleaning

All equipment requiring cleaning was cleaned in accordance with Section 11.0 of Appendix A of the SDCP. All pipe was inspected and cleaned prior to being used.

2.5.4 Program Modifications

Due to the possibility that grout was affecting the permeability of the bedrock in well OW659D (ie the well was pumped dry during development and a recovery rate of approximately 0.7 gpm was observed), the diameter of the borehole was enlarged to a 6 inch diameter to remove rock which may have been coated with grout. The well was pumped dry following enlargement and an increased recovery rate of approximately 1 gpm was observed.

3.0 GEOLOGIC AND HYDROGEOLOGIC SUMMARY

3.1 STRATIGRAPHIC DATA

A series of bedrock wells were installed during Phase 2 of the OSI Program in the off-Site area to collect additional geologic and hydrogeologic information. Geologic and hydrogeologic information from the three UDG wells within the study area was also obtained. The Stratigraphic and Instrumentation Logs are contained in Appendix A. The information from the Phase 2 OSI Program has been summarized on the following tables contained in Appendix C:

C1	Stratigraphic Data - Off-Site Investigation Program
C2	Overburden Stratigraphic Thickness - Off-Site Investigation Program
C3	Bedrock Stratigraphic Thickness - Off-Site Investigation Program
C4	Bedrock Monitoring Intervals - Off-Site Investigation Program

Table C1 contains the following information for each installation: ground surface elevation, horizontal survey data presented in terms of the N-Area Grid coordinate system, depth and elevation of each stratigraphic unit encountered, and occurrence of NAPL or iridescent sheens.

Based on the information contained in Table C1, the thickness of each overburden stratigraphic unit has been determined and is presented in Table C2. The stratigraphic thickness for each bedrock unit encountered during Phase 1 and 2 of the OSI Program is presented in Table C3. Table C4 presents the monitoring intervals and units for each of the bedrock wells.

For reference, the stratigraphic information for the Plant can be found in one of the following documents:

Historical Information	- Historical Data Base, Buffalo Avenue Plant, June 1984, Appendix A.

SDCP Overburden Information	-	Overburden Summary Report, Appendix A, November 1989.
SDCP Bedrock Information	-	Bedrock Information Summary Report, March 1991.

3.2 OVERBURDEN GEOLOGY

In general, the OSI - Phase 2 hydrogeologic investigations support the descriptions provided in the OSI Summary Report. Specific differences identified during Phase 2 are presented below. In general, the overburden materials within the off-Site area are comprised of the following four stratigraphic units: Fill Material, Alluvial River Deposits, Glacial Lake Deposits and Glacial Till.

Fill Material

The Phase 2 results are consistent with the description of the Fill Material provided in the OSI Summary Report. Thus, no changes in the fill description are required.

Alluvial River Deposits

The OSI Summary Report stated that the Alluvial River Deposits (alluvium) ranged in thickness up to 10 feet. Phase 2 information showed that the unit ranged in thickness up to 11 feet with an average thickness of 3.6 feet.

Glacial Lake Deposits

The Phase 2 results confirmed that the thickness of the Glacial Lake Deposits (clay) varied across the OSI study area and reached a maximum thickness of 12 feet with an average thickness of 6.0 feet.

Glacial Till

The OSI Summary Report stated that the Glacial Till (till) thickness ranged up to 4.5 feet. The Phase 2 results showed that the thickness of this unit ranged up to 7 feet with an average thickness of 3.5 feet.

3.3 BEDROCK GEOLOGY

In general, the OSI - Phase 2 hydrogeologic investigations support the descriptions provided in the OSI Summary Report. A summary of the bedrock geology, including specific differences identified during Phase 2, are presented below. The stratigraphic sequence of the bedrock within the OSI study area consists of the Oak Orchard, Eramosa, Goat Island and Gasport Formations of the Lockport Group. Site-specific stratigraphic information for these units for the Phase 2 wells is summarized in Table C3. Figure 3.1 presents the orientation of a cross-section of the Lockport Group. Figure 3.2 presents the bedrock cross-section A-A'.

The lithology and thickness ranges of the formations were as follows:

Oak Orchard	73 to 81 feet thick	bituminous, light to dark gray, very thin to medium bedded, fine to medium grained saccharoidal dolostone
Eramosa	11 to 20 feet thick	bituminous, light to medium gray, thin to medium bedded, fine to medium grained argillaceous dolostone
Goat Island	11 to 15 feet thick	bituminous, medium to dark gray, thin to medium bedded, fine to medium grained dolostone

Gasport	thickness not determined (typically 30 feet thick)	bituminous, medium to dark gray, very thin to medium bedded, fine to medium grained dolomitic limestone

The bedrock stratigraphic thicknesses measured during the OSI-Phase 2 study are summarized in Table 3.1.

3.4 OVERBURDEN HYDROGEOLOGY

The hydrogeologic characteristics of the overburden in the OSI study area were confirmed by the installation of the OSI - Phase 2 wells. In the OSI study area the overburden waterbearing unit ranged in thickness from 2 feet to 15 feet and the underlying confining layer ranged from 7 feet to 12 feet thick.

3.4.1 Hydraulic Conductivities

The OSI - Phase 2 overburden wells were not tested to determine hydraulic conductivity.

3.4.2 Groundwater Movement

A detailed description of overburden groundwater movement in the OSI study area can be found in the OSI Summary Report.

2.14 2.15

The overburden groundwater contours presented on Figures ~~2.13~~ and ~~2.14~~ for the May and July 1993 groundwater levels respectively confirm the groundwater flow directions presented in the OSI Summary Report. In general, the groundwater contour patterns shown on Figures 2.13 and 2.14 are similar.

2.14 2.15

Figures 2.13 and 2.14 show that the overburden groundwater is influenced by local effects. The EBDTS acts as a line sink drawing overburden groundwater toward the Plant from off-Site areas north of the Plant. The 47th Street sewer acts as a localized groundwater sink, drawing groundwater toward it from the surrounding areas. The EBDTS and other underground utilities are discussed more fully in the OSI Summary Report.

A downward vertical gradient exists in the OSI study area between the alluvium/fill unit and the monitored bedrock zones as illustrated by the OSI water level data.

Overburden groundwater levels measured during the OSI-Phase 2 study are summarized in Table 3.2.

3.5 REGIONAL BEDROCK HYDROGEOLOGY

A detailed discussion of the regional bedrock hydrogeology can be found in the OSI Summary Report.

3.6 OFF-SITE BEDROCK HYDROGEOLOGY

The OSI - Phase 2 studies, which included hydraulic properties testing such as in-situ injection testing, support the off-site hydrogeology presented in the OSI Summary Report.

3.6.1 Hydraulic Conductivities

Injection tests were performed in conjunction with the installation of the OSI - Phase 2 bedrock wells. Appendix B shows the results of this testing. The OSI- Phase 2 hydraulic conductivity values were similar to those determined from the OSI - Phase 1 study and on-Site programs.

All bedrock intervals tested during the well installations at well nests OW652, 653, 657, 658 and 659 were found to be waterbearing except the 20 feet to 50 feet below top of rock (BTOR) interval and the 100 feet to 120 feet BTOR interval at OW653, the 20 to 35 feet BTOR interval at OW658, and the 50 feet to 65 feet BTOR interval at OW659. A waterbearing unit is defined as a unit with a hydraulic conductivity of 5×10^{-5} cm/sec or greater.

The injection test results show that the hydraulic conductivity values for the D-Zone ranged from 7.8×10^{-6} to 3.6×10^{-1} cm/sec. The C-Zone hydraulic conductivity values ranged from 3.9×10^{-4} to 3.2×10^{-2} cm/sec. The B-Zone hydraulic conductivity values ranged from 2.5×10^{-5} to 1.1×10^{-1} cm/sec.

3.6.2 Bedrock Groundwater Movement

Figures 2.6 to 2.11 present the bedrock groundwater contours for the intervals monitored by the D, C, and B-Zone wells, respectively. These water levels were measured in May 1993 and July 1993.

The groundwater flow directions shown on Figures 2.6 to 2.11 confirm the flow directions presented in the OSI Summary Report. In summary, the groundwater flow direction in the D-Zone bedrock (Figures 2.6 7 and ~~2.9~~ 2.10) was north/northwest towards the NYPA power conduits and the Falls Street Tunnel. The northerly limit of groundwater flow in the D-Zone is the Falls Street Tunnel which has also been identified to be a line sink for groundwater flow. The westernmost limit for bedrock groundwater flow from the Plant is the NYPA power conduits. These conduits sever the D, C and B Zones in the bedrock and physically cut off all northwesterly groundwater flow in these zones from the Plant.

Groundwater elevations for the C-Zone wells are shown on Figures ~~2.7~~ 2,8 and ~~2.10~~ 2.11. The groundwater flow pattern across this bedrock zone was similar to that of the D-Zone bedrock groundwater system with groundwater flow towards the north/northwest. The vertical gradient between the units monitored by the C and D-wells was small and fluctuated between upwards and downwards at various well locations.

Groundwater elevations for the B-wells are shown on Figures ~~2.8~~ 2.9 and ~~2.11~~ 2.12. Groundwater flow was generally towards the north/northeast. The vertical gradient between the units monitored by the B and C-Zone wells was downward with a potentiometric differential ranging on the order of less than one foot to over two feet.

Bedrock groundwater levels measured during the OSI-Phase 2 study are summarized in Table 3.3.

A detailed discussion of the subsurface structures which exert the most influence on bedrock groundwater flow in the OSI study area is presented in the OSI Summary Report.

4.0 CHEMICAL PRESENCE SUMMARY

4.1 NAPL PRESENCE

4.1.1 Overburden NAPL Observation

No overburden soils containing NAPL were observed during the drilling operations for any of the Phase 2 OSI well installations.

4.1.2 Bedrock NAPL Observation

NAPL was observed once during the OSI Phase 2 well depth sounding activities of OW655D. Measurement of the total well depth at OW655D showed 1.3 feet of sediment in the bottom of the well and 0.4 feet of NAPL overlying the sediment. NAPL was not detected in any other new or existing bedrock location during the OSI Phase 2 studies.

On June 9, 1993 a sample of the NAPL from OW655D was collected and analyzed pursuant to the NAPL analytical protocols described in Appendix C of the SDCP. Analytical results are presented in Appendix D.

The analysis of the OW655D NAPL showed the primary components to be chlorobenzenes (61 percent) and chlorotoluenes (6 percent). Although chlorotoluenes were not included in an analysis of a NAPL sample collected from Frontier Chemical's well MW-84-11 performed by ECCO Incorporated, chlorobenzenes accounted for 93 percent of the concentrations of detected compounds. This demonstrated that the NAPL found in OW655D and the NAPL found in MW-84-11 were similar.

4.2 GROUNDWATER ANALYTICAL SUMMARY

The analytical protocols used for the OSI - Phase 2 Sampling Program were those described in the SDCP document entitled, "Appendix C - Chemical Sampling and Quality Assurance Plan - April 1988".

Each of the groundwater samples collected during the OSI - Phase 2 were analyzed for the SSI parameters shown in Table 2.3.

In order to present the results of the SSI, the parameters have been subdivided into parameter groups representative of the chemical families to which they belong. Since these chemical families would typically have been manufactured in the same areas and handled in a similar manner, combining them for presentation purposes is appropriate. The chemical families into which the SSI parameters have been grouped are presented in Table 4.1. Am Ref fuel Co Res Rec Fac (EFW)

Bedrock groundwater samples were collected on March 8 and 9, 1993 by ARC/GZA at the RRF as part of ARC's environmental study of the RRF. The bedrock groundwater samples were analyzed for priority pollutant (PP) volatile organic compounds (VOCs), PP base/neutral acid extractables (BNAs), PP pesticides/PCBs, PP metals, and dechlorane plus. The RRF foundation drain sample was analyzed for target compound list (TCL) VOCs and BNAs, Resource Conservation and Recovery Act (RCRA) metals (plus aluminum, copper, lead and zinc), dechlorane plus, and sulfate. A summary of the analytical parameters and methodologies are presented on Table 4.2. The analytical results and QA/QC review are included as Appendix E.

4.2.1 Overburden Groundwater Chemistry

Groundwater samples were collected from three overburden wells during Phase 2 of the OSI program. UDG wells MW-2 and MW-3 were sampled during Round 1 and well MW-1 was sampled during Round 2. The results demonstrate that there is minimal chemical presence north of the area where OW554 is located. Well OW554 had exhibited the highest off-Site chemical presence in Phase 1 of the OSI.

To graphically present the overburden SSI results, the analytical data have been plotted adjacent to the respective well locations (see

Figures 4.1.1 through 4.1.4). The concentration of parameters of each chemical family have been summed and are reported as a total concentration on the figures. The following subsections discuss the chemical presence shown on Figures 4.1.1 through 4.1.4. Due to the low concentrations of chemicals present and minimal parameter detection, only four parameter/parameter groups are presented in a figure format.

<u>Total Organic Halides (Figure 4.1.1)</u>

TOX data from the UDG wells sampled has been rejected due to laboratory deficiencies (see Appendix F - QA/QC Summary). For reference the TOX results for adjacent wells from previous studies have been presented.

<u>Total Organic Carbon (Figure 4.12)</u>

Total Organic Carbon (TOC) concentrations were not detected at a method detection level of 3 mg/L and 6 mg/L (MW-2, MW-3 Round 1) and 4 mg/L (MW-1, Round 2).

<u>Total Soluble Phosphorus (Figure 4.1.3)</u>

Total soluble phosphorus concentrations were low, ranging from not detected at a method detection level of 10 µg-P/L (MW-3, Round 1) to 14 µg-P/L (MW-2, Round 1) and 17 µg-P/L (MW-1, Round 2).

<u>Total Organic SSI Concentrations (Figure 4.1.4)</u>

Organic SSI parameter presence was limited to trichloroethylene at a concentration of 3 µg/L (MW-3, Round 1), and tetrachloroethylene at a concentration of 7 µg/L (MW-2, Round 1). No other analytes were detected at MW-2, MW-3 or MW-1 (Round 2).

Lead (No Figure)

Lead concentrations ranged from not detected at a method detection level of 30 μg/L (MW-2, Round 1) to 37 μg/L (MW1, Round 2) and 41 J μg/L (MW3, Round 1).

Arsenic, Mercury (No Figures)

Arsenic and mercury were not detected above their respective method detection levels in any UDG overburden well sampled (MW-1, MW-2, MW-3).

Acids

None of the acids (benzoic acid, 2-chlorobenzoic acid, 3-chlorobenzoic acid, 4-chlorobenzoic acid, and chlorendic acids) were detected above their respective detection limits.

4.3 BEDROCK GROUNDWATER CHEMISTRY

The purpose of the Phase 2 OSI bedrock SSI Survey was to provide additional groundwater chemical data suitable for defining the extent of the chemical plume from the Plant into the OSI study area bedrock groundwater regime. Of primary importance was to determine whether the chemicals found along Royal Avenue were connected to the chemical plume beneath the Plant. The gap in the data base existed in the off-Site area 1,000 feet from the Plant boundary. The new wells provided the information necessary to fill this gap.

The collection of groundwater samples from the OSI bedrock wells for Phase 2/Round 1 - SSI was conducted during May 1993. Phase 2/Round 2 sampling was conducted in July 1993. The samples were analyzed for the SSI parameters listed in Table 2.3.

Bedrock groundwater samples were collected by ARC in March 1993 and were analyzed for the parameters listed in Table 4.2. The ARC samples were collected between OSI Phase 1 and Phase 2. Since the ARC samples were analyzed for different parameter lists (i.e. PP and TCL) and the OxyChem samples were analyzed for the SSI parameters, some analytes included in one list are not included in the other list. Thus, it is not possible to provide a comparison between the ARC and OxyChem results for analytes which are not common to the lists. The discussion below for the ARC analytical results focuses on the common analytes.

The ARC analytical results shown on Table 2.1 of Appendix E show that low level concentrations of principally chlorobenzene and chloroethylene compounds were detected. The ARC and OxyChem concentrations for well OW650 are generally consistent except for the chlorobenzene compounds. The ARC chlorobenzene compounds analytical results show higher concentrations (8.6 to 69 μg/L) than the OxyChem analytical results which ranged from ND1 to 2 μg/L.

The ARC analytical results for OW653D, OW407C and the RRF foundation drain are presented on Tables 2.2, 2.3 and 2.4 respectively in Appendix E. The principal compounds detected were chlorotoluene, chlorobenzene, and chlorobenzotrifluoride compounds. For the chlorobenzene compounds, the analytical results for the above three sample locations are consistent (i.e. the concentrations are of the same order magnitude). Since the ARC analytical results are generally consistent with OxyChem's analytical results, further discussion of the ARC results is not required and the following discussion utilizes OxyChem data only.

The Phase 2 - SSI analytical results for Round 1 and Round 2 for all monitoring intervals have been plotted adjacent to their respective well locations (see Figures 4.2.1 through 4.2.24) with the previous Phase I OSI results and SDCP results from selected Plant boundary wells. The concentrations of parameters of each chemical family have been summed and are reported as a total concentration on the figures (see Table 4.1 for parameter groupings).

Table 4.3 presents a comparison of the average chemical concentrations found in the D-interval 1,000 feet north of the Plant boundary with that of the D-interval wells located along the Plant boundary and the wells along Royal Avenue 1,500 feet north of the Plant boundary (south of the Falls Street Tunnel). Consistent with the OSI Summary Report a pattern of chemical presence emerges which showed elevated chemical presence along the Plant boundary and Royal Avenue (1,500 feet) whereas the chemical concentrations decreased in the area 1,000 feet from the Plant boundary. As shown in Table 4.3 the average concentrations for 14 of the 18 comparable parameter groups decreased when the first line of wells (1,000 feet - OW651D, OW652D, OW653D, OW657D, OW658D and OW659D) are compared to the Plant boundary wells (OW404D, OW405D, OW406D, OW408D and OW417D). Comparison of the parameter groups for the first line of wells (1,000 feet) with the Royal Avenue wells (1,500 feet) shows that the average concentration of 7 of the 18 comparable parameter groups was higher at the Royal Avenue wells (OW654D/OW655D) than at the first line of wells. The average concentration for 9 parameter groups at the Royal Avenue wells was similar to that for the first line of wells; two parameter groups increased in concentration from the Royal Avenue Wells to the first line of wells.

Tables 4.4 and 4.5 present a comparison of the average chemical concentrations found in the C-Zone and B-Zone wells 1,000 feet north of the Plant boundary with those of the C-Zone and B-Zone wells located along the Plant boundary and the well (OW654) along Royal Avenue 1,500 feet north of the Plant boundary.

Consistent with the pattern described above for the D-Zone, elevated chemical concentrations were detected in the C-Zone along the Plant boundary and Royal Avenue whereas the chemical concentrations decreased in the area 1000 feet from the Plant boundary. As shown in Table 4.4, the average concentrations for 10 of the 18 comparable parameter groups decreased when the first line of wells is compared to the Plant boundary wells. The remaining 8 of the 10 comparable parameter groups were ND for both lines of wells. Comparison of the parameter groups for the first line of wells with the Royal Avenue wells shows that the average concentration of 3 of the 18 parameter groups, including total organic SSI, were higher at the Royal Avenue wells, 6 of the 18 were lower, and 9 of the 18 were ND for both lines of wells.

The average chemical concentrations shown in Table 4.5 for the B-Zone show a different pattern than observed for the D and C-Zones. In the B-Zone, the chemical concentrations for the majority of the 18 comparable parameter groups (16 of the 18 from Plant boundary wells first line wells and 14 of the 18 from the first line wells to Royal Avenue wells) either decreased or were the same. The two parameter groups that increased in concentration from the Plant boundary wells to the first line wells were total soluble phosphorus and total chloroethylenes. The four parameter groups that increased in concentration from the first line of wells to the Royal Avenue wells were total soluble phosphorus, total chlorotoluenes, benzene and total HCCH. Comparison of the Plant boundary wells with the Royal Avenue wells shows that 19 out of 20 comparable parameter groups (adding TOX and specific conductance which were qualified as rejected and not available, respectively, for the first line wells) decreased in concentrations from the Plant boundary to Royal Avenue. The one parameter that consistently increased in concentration with distance from the Plant was total soluble phosphorus.

Tables 4.6, 4.7 and 4.8 present a comparison of the average chemical concentrations found the three lines of wells (i.e. Plant boundary, first line and Royal Avenue) with depth (i.e. D, C and B-Zones).

Table 4.6 shows that the highest concentrations in the Plant boundary wells were detected in the D-Zone, followed in order of decreasing concentration by the B-Zone and then the C-Zone.

Table 4.7 shows that the total organic SSI chemical concentrations in all three intervals for the first line wells, while increasing with depth, were of the same order of magnitude. The primary reason for the increase in concentrations with depth was elevated benzene (1,200 µg/L) and chlorobenzene (1,600 µg/L) concentrations in OW659B; whereas only low level concentrations of benzene (4 µg/L) and chlorobenzene (86 µg/L) were detected in OW659D. This occurrence is directly attributable to the pattern of bedrock groundwater migration (i.e. vertically downward and horizontally to the north/northeast from the Plant in the D and C-Zone and to the north/northeast from the Plant in the B-Zone). Upgradient of well nest OW659, SDCP studies identified elevated D, C and B-Zone benzene and total chlorobenzene concentrations at the Plant boundary well nests OW405 and OW406. At these locations, concentrations of benzene ranged from 2900 to 27,000 µg/L (D-Zone), 1,300 to 5,500 µg/L (C-Zone), and 3,200 µg/L to 25,000 µg/L (B-Zone). Chlorobenzene concentrations ranged from 14,000 to 20,000 µg/L (D-Zone), 7,900 to 11,000 µg/L (C-Zone), and 2,800 to 24,000 µg/L (B-Zone).

Table 4.8 shows a pattern of decreasing concentration with depth for the Royal Avenue wells. The dominant parameter groups detected in the D-Zone were total chlorotoluenes, benzene, total chlorobenzenes and total chloroethylenes. The dominant parameter group for the C-Zone was total chloroethylenes. The dominant parameter groups for B-Zone were total chlorotoluenes, benzene and total chlorobenzenes.

A detailed discussion of chemical distribution is presented below, dividing the chemical presence along the 1,000-foot alignment into three categories (i.e. non-detection, chemical presence less than one ppm, and chemical presence greater than one ppm) and comparing these chemical level categories to the Plant boundary and Royal Avenue areas. This discussion clearly shows the distinct chemical plume originating from the Plant proper, and the chemical plume originating from areas north of Royal Avenue:

- Non Detection

  In the vicinity of the 1,000-foot alignment of bedrock monitoring wells, TOC; total mercury; total lead; total arsenic; toluene; total hexachlorobutadiene, hexachlorocyclopentadiene, octachlorocyclopentene and perchloropentacyclodecane; 2,4,5-trichlorophenol; total hexcachlorocyclohexanes, benzoic acid, total chlorobenzoic acids and chlorendic acid were all generally found to be in the non-detect to low µg/L (mg/L for TOC) range of concentration.

Total mercury; total lead; total arsenic; 2,4,5-trichlorophenol, total chlorobenzoic acids and chlorendic acid were essentially non-detect at the Plant boundary and in the Royal Avenue areas, subsequently, no further discussion is warranted. TOC concentrations along Royal Avenue ranged from ND (PASNY 139) to 80 mg/L (MW-88-6B); whereas TOC concentrations along the Plant boundary or the 1,000-foot well alignment did not exceed 18 mg/L.

Toluene concentrations along Royal Avenue and the Plant boundary within the D Zone were present at concentrations of 460/590 µg/L (MW-88-6B), 230 µg/L (MW-88-6A); and 84/25 µg/L (OW404D), 82/130 µg/L (OW405D); whereas toluene was essentially non-detect to trace concentrations (i.e. <3 µg/L) along the 1,000-foot alignment.

Total hexachlorobutadiene, hexachlorocyclopentadiene, octachlorocyclopentene, perchloropentacyclodecane; and total hexachlorocyclohexanes were detected at OW654D and MW-88-6B (Royal Avenue) and at OW404 and OW405B,C,D (Plant boundary), whereas along the 1,000-foot alignment these compounds were essentially non-detect to trace concentrations.

Benzoic acid was only detected in the Royal Avenue area at one well (MW-88-6B) at a concentration of 620/1,800 µg/L. Benzoic acid was not detected at any Plant boundary well nor along the 1,000-foot alignment.

- <u>Less Than One mg/L</u>

In the vicinity of the 1,000-foot alignment of bedrock wells, total organic halides (TOX), total chlorobenzotrifluorides, total chloroethylenes, total chlorotoluenes and total soluble phosphorus were generally present at concentrations of 1 mg/L or less.

TOX concentrations along the 1,000-foot alignment were typically non-detect to 800 µg/L (OW653D), whereas along the Plant boundary elevated levels generally ranged from 1,000 µg/L to 31,000 µg/L. In the